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APPLICATION OF HEAT PUMP IN VACUUM DRYER

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Relevance of research. Heat pump drying is proposed to be the most efficient due to the simplicity of the dryer design and the high level of latent heat recovery. In addition, it has the advantages of good product quality, possibility of temperature and humidity variations, excellent control of drying conditions, possibility of recovery of volatile substances etc. [1-3]. Principle of a heat pump is a part of hybrid or combined drying. Hybrid or combined drying technologies include carrying out of various regimes of heat transfer in the same or different dryers. Normally, the amount of heat absorbed by a wet material in a dryer varies from 5 to 10% of the supplied energy. The 95–90% of this energy may be recovered by means of a heat pump assisted drying, leading to substantial energy savings [4].

A heat pump drying system consists of two subsystems: a heat pump (refrigeration system) and a drying chamber. The drying chamber may be made of a tray, fluid bed, rotary or band conveyor.

There is a wide variety of designs for heat pump dryers.: split drying heat pump system, two-stage series evaporator drying heat pump system coupled with a drying chamber, two-stage modular heat pump dryer, two-stage parallel evaporator heat pump drying system. two-cycle heat pump dryer, two-stage compression heat pump etc.[5].

At the same time, the use of heat pumps in vacuum dryers, which require significant energy consumption, is relevant. The use of a heat pump in a vacuum dryer circuit will reduce energy costs for removing moisture from the material while preserving the biochemical composition of the dried product.

The purpose of researchisto develop the design of a vacuum dryer using the principle of operation of heat pumps.

The authors of the article proposed the design of a hybrid dryer that combines vacuum drying and atmospheric post-drying (Fig.1). Atmospheric post-drying is based on a heat pump: post-drying of the material released from the vacuum dryer is carried out in an atmospheric dryer, where the heat of condensation of the refrigerant is used to heat the air.

Basic research materials. The developed installation includes a vacuum drying unit for thermolabile materials, a heat pump unit and an atmospheric final drying unit.The vacuum drying unit includes a vacuum chamber, a vacuum pump and a moisture freeze-out device, which is the evaporator of the refrigerating machine. The vacuum chamber is a cylindrical metal container with a hermetically sealed lid. There are shelves for placement drying material are fitted inside vacuum chamber. Necessary vacuum level in the chamber is provided by a vacuum pump, and the required pressure level is regulated by a vacuum valve.

The heat pump unit is a single-stage freon refrigeration machine included in the scheme of the dryer. This can significantly reduce the drying time of the material and reduce energy costs for the finished product due to the parallel implementation of vacuum and atmospheric drying of the material. In addition, the inclusion of the refrigerating machine in the scheme reduces the load on the vacuum pump by removing moisture vapors evaporating from the dried material with a moisture freeze-out device.The unit of atmospheric drying includes the device of thermal drying of thermolabile materials, the condenser of the refrigerating machine and the axial fan. Drying material is placed on mesh shelves. The condenser is an element of the refrigerating machine and is intended for heating the drying agent. Air is used as a drying agent. The drying agent is pumped into the thermal drying device by an axial fan. The uniformity of the blowing of the dried material is ensured by adjusting the rotation of the louver nozzles installed in the lower part of the thermal drying device.Energy savings are achieved using the principle of obtaining cold and heat, which is the basis for the operation of heat pumps.

The principle of operation of the installation is described earlier[6].

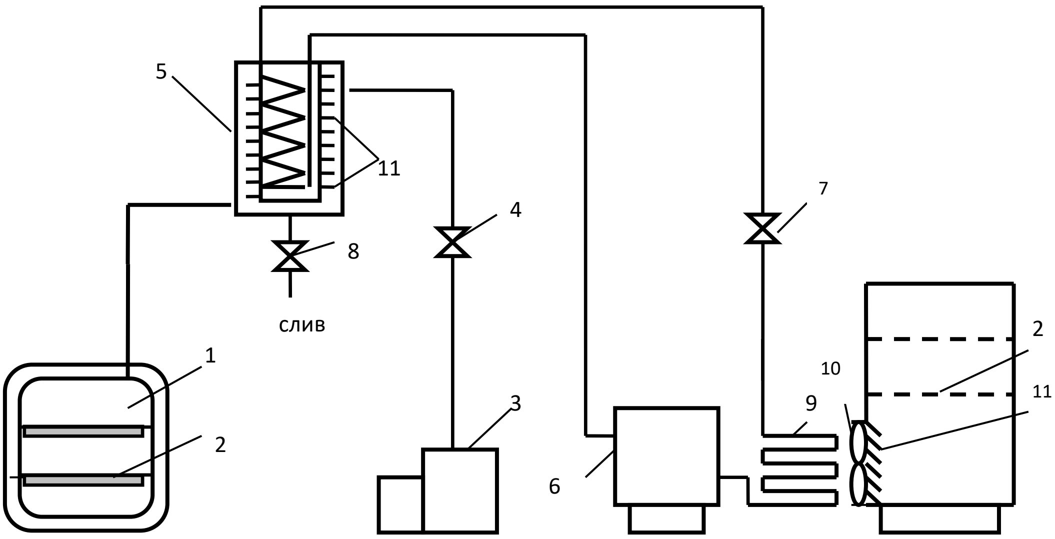

Figure 1. - Scheme of experimental vacuum-atmospheric dryer.
1 – vacuum chamber; 2 – shelves; 3 – vacuum pump; 4 – vacuum valve; 5 – evaporator; 6 – reciprocating compressor; 7 – expansion valve; 8 – valve; 9 – air condenser; 10 – axial fan; 11 – перегородки

In order to determine the economical mode of drying, the cost of electricity was calculated for the removal of 1 kg of moisture, taking into account energy-consuming sources: electric heaters, a vacuum pump, a refrigeration compressor and an air condenser fan.

Conclusion. The essence of combining vacuum drying with atmospheric drying is to include a heat pump in the vacuum drying installation, which provides heat for the process of atmospheric drying of the material and cold for the process of freezing moisture during vacuum drying. A good preservation of the biochemical composition of the dried products and a decrease in the energy consumption of vacuum-atmospheric drying compared to vacuum drying by 13-46% were noted, depending on the type of material being dried (solid or liquid).

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